AN INTERDISCIPLINARY STUDY OF THE ESTUARINE AND COASTAL OCEANOGRAPHY OF BLOCK ISLAND SOUND AND ADJACENT NEW YORK COASTAL WATERS

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June 1973
Interim Report for Period January through June 1973

Prepared for:

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Gov. Acession No.	3. Recipient's Catalog No.
4. Title and Subtitle "An Interdisciplinary Study of the Estuarine and Coastal Oceanography of Block Island Sound and Adjacent New York Coastal Waters"		5. Report Date June 1973 6. Performing Organization Code
7. Author(s) Edward F. Yost		8. Performing Organization Report No. TR-20-II
9. Performing Organization Name & Address Science Engineering Research Group C.W. Post Center-Long Island University Greenvale, New York 11548		10. Work Unit No. 11. Contract or Grant No. NAS5-21792
12. Sponsoring Agency Name & Address Mr. Edmund F. Szajna Goddard Space Flight Center Greenbelt, Maryland 20771		13. Type of Report and Period Covered Type II - Jan.-June 1973 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

ERTS-1 imagery of New York coastal waters has been photographically enhanced to emphasize apparent water color differences. Water samples have been collected simultaneously with the acquisition of satellite data. Water turbidity, particularly that arising from sewage dump areas,and sediment discharge from coastal inlets correlate well with the ERTS-1 color signatures.

17. Key Words (Selected by Author(s))	18. Distribution Statement
Coastal Remote Sensing	

19. Sec. Classif. (of this report)	20. Sec. Classif. (of this page)	21. No. of Pages	22. Price*
U	U	22	

*For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Table of Contents

Preface

The task of correlating ERTS-1 image characteristics of coastal water with the physical, optical, chemical, and biological properties of water has continued. The multispectral photographic imagery from ERTS-1 has been photographically enhanced to give spectral color signatures which correlate with water turbidity. The data from an extensive water sampling effort is being reduced in order to provide thematic charts of water turbidity related to color image signatures acquired from ERTS-1 data.

Section 1

Introduction

This report is prepared in regard to NASA Contract NAS5-21792 for "An Interdisciplinary Study of the Estuarine and Coastal Oceanography of Block Island Sound and Adjacent New York Coastal Waters". This interim progress report covers the period January through June 30, 1973. The initial preparation, field work, and imagery analysis for the period July through December 31, 1972 has been documented in the SERG report TR-20-I submitted in December 1972.

This project was undertaken by Long Island University and New York Ocean Science Laboratory as a joint effort to study the characteristics of the waters of Block Island Sound and New York Bight as they may relate to ERTS imagery.

"First look" analysis of the imagery was performed and candidate frames were selected depending upon the extent of cloud coverage over the area of interest. Phase III activity under this contract was begun from April 1973. The additive color analysis of the imagery in the earlier stages of this study had revealed that it was necessary to photographically reprocess the imagery received from NASA to show the presence of subtle spectral differences in the water.

The ground truth experiments were undertaken by the New York Ocean Science Lab. In order to collect water sample data which is relevant to the characteristics being detected on the multispectral imagery, the ground truth collection program was modified as compared to methods used

in earlier parts of this investigation. Surface data at a large number of stations was obtained instead of concentrating on "in depth" sampling at a relatively small number of stations.

Ten cruises involving the research vessel KYMA were planned for the reporting period January through June 1973 to collect water samples in Block Island Sound and New York Bight. Eight of the ten planned cruises were executed and two had to be terminated due to bad weather. During each cruise, samples were collected for temperature, salinity, nutrients, oxygen, pigments, organics, phytoplankton, light attenuation, and fluorometric readings. It is estimated that as of this time, approximately 90 percent of the field sampling effort has been completed. The physical, chemical, and biological oceanographic analysis of this data is underway so as to relate the water characteristics to the ERTS imagery.

Section 2

Multispectral Photo Analysis and Ground Truth Collection

Underflight and ERTS imagery were analyzed in order to determine the hydrologic features of the water mass in Block Island Sound and New York Bight area. The ERTS imagery exposed on 28 July 1972 for Block Island Sound had indicated that photographic reprocessing of the negatives received from NASA was necessary in order to enhance the water detail and bring out the subtle spectral differences. The spectral bands included the 500-600 nm, 600-700 nm, 700-800 nm, and 800-1100 nm regions.

Phase III activity under this contract was begun from April 1973. Candidate frames were selected for multispectral photo analysis from the imagery received from NASA. The extent of the cloud coverage over the area of interest was taken into consideration in such a selection. A multispectral photo analysis of the New York Bight area was also made using ERTS imagery for October 9 and October 10, 1972. The results of the analysis showed that a time sequential multispectral color presentation relates color to environmental changes as a function of time, rather than spectral changes for any single date. It is believed that this mode of data reduction would be employed further in conjunction with the conventional techniques. Additive color analysis was also performed on ERTS frame numbers 1167-15013, 1185-15015, and 1186-15075. These photographs were taken on the 6th, 24th, and 25th of January 1973 respectively. Positive color prints were made by using different multispectral renditions at a scale of 1:500,000. These frames and other

imagery taken on the 16th of August and 9th of October 1972 were viewed by Science Engineering Research Group personnel together with personnel from the New York Ocean Science Laboratory. One of the frames used in the analysis is presented in this report.

Multispectral Additive Color Analysis

Frame No. 1186-15075 of the ERTS data was selected for the study of the New York Bight area and the South Shore of Long Island. This frame was taken by the satellite on January 25, 1973 and is almost cloud free. Also taken into consideration was the fact that cruise K-7302 was successfully executed to collect water samples for oceanographic analysis in the New York Bight area on January 25, 1973.

Figure 1 shows the general region covered by the frame which has been analyzed using additive color techniques. Also included in this figure is the location of various stations at which the oceanographic measurements were taken on 25 January 1973.

Quick-look analysis of the NASA supplied set of imagery indicated that:

-- The green band lacked contrast
-- The red spectral band was of acceptable contrast
-- The exposure was good for the water area in the infrared bands, but it lacked detail in both the water and land areas.

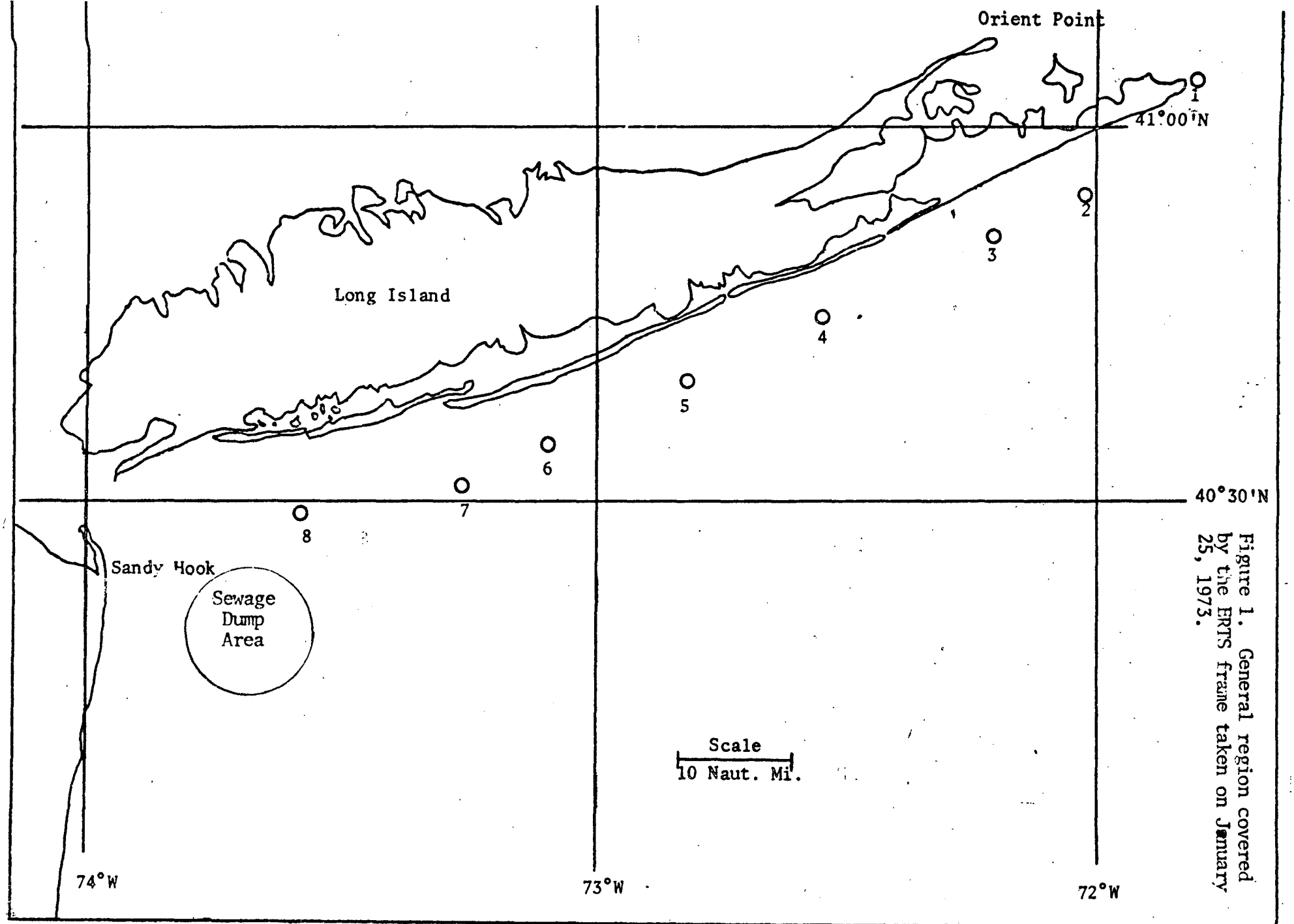


Figure 1. General region covered by the ERTS frame taken on January 25, 1973.

NASA supplied positive imagery for Frame No. 1186-15075, shown in Figure 2, was placed into the Spectral Data Model 64 viewer and the spectral records were projected as follows:

500-600 nm Band - Red

600-700 nm Band - Green

700-800 nm Band - Blue

800-1100 nm Band - Blue

Only one of the infrared bands was projected at a time with the two visual bands. No obvious differences in water mass were apparent in this color composite image. Because of the non-optimal development of multispectral data for either the land or water area, the NASA imagery was reprocessed at Long Island University.

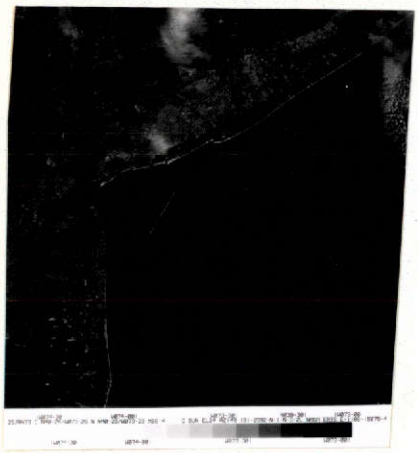
The negatives supplied by NASA were used to generate a second set of positives which would enhance any detail in the water. The second generation set of these reprocessed positives was used to produce the color composite shown in Figure 3. Only one of the infrared bands was used in this multispectral rendition. The spectral records were projected as follows:

500-600 nm Band as Red

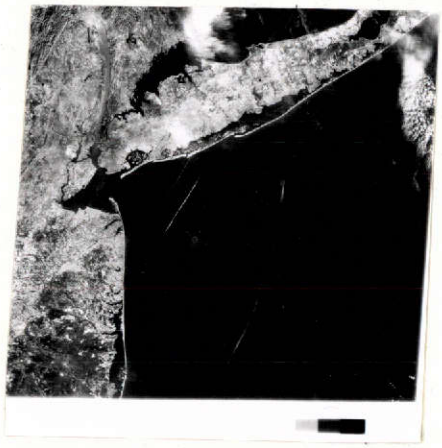
600-700 nm Band as Green

700-800 nm Band as Blue

The multispectral rendition was viewed on the viewer screen for the subtle spectral differences in the water mass in the New York Bight area. The viewer screen was photographed and positive prints were made using a scale of 1:500,000.



500 - 600 nm Band



600 - 700 nm Band

700 - 800 nm Band

800 - 1100 nm Band

Figure 2. Four multispectral scanner positives of Frame 1186-15075 taken on 25 January 1973 as received from NASA.

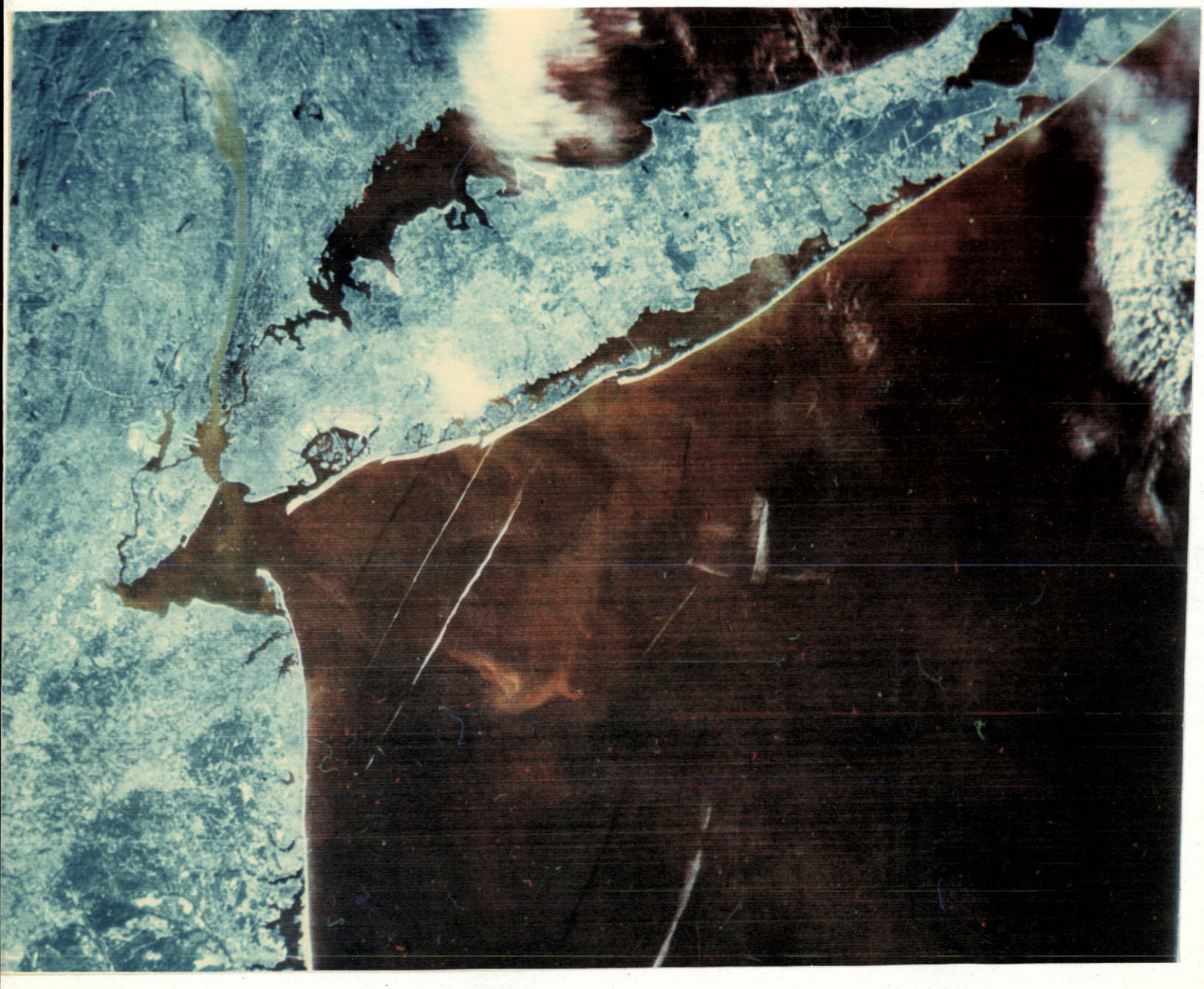


Figure 3. Additive color composite made from ERTS MSS bands 4, 5, and 6 of Frame 1186-15075 taken on 25 January 1973.

Notice that all detail in the land area has been lost since the reprocessing to obtain a second generation set of positives was done to enhance water detail. The land area covered with vegetation appears as blue since the infrared record was projected as blue. The extent of the urbanization in the land area is indicated by the loss of blue color in different parts of the image.

A comparison of the color composite shown in Figure 3 was also made using the ERTS photographs taken on 16 August and 9 October 1972. Certain features were observed in these photographs relating to a colored water mass off Long Island and visible signs of pollution in the dump areas in New York Bight. Although there was not any significant change in the color for New York Bight dump area in this comparison, it is interesting to notice the change in shape and size. Discussion on this feature with oceanographers from New York Ocean Science Laboratory indicated that this change in the shape and size as compared to previous visual detection could be attributed to the change in the method of dumping the sewage or it could be due to the high velocity winds in the northeast direction.

The yellowish-red color of the water mass along the South Shore of Long Island is evident in the color composite as compared to the dark greenish color of water in the lower right-hand portion of this photograph. The water samples were collected on 25 January 1973 along the South Shore at the different locations shown in Figure 1. The analysis of the oceanographic data showed that the yellowish-red color off the South Shore was due to the heavy suspended particulant with an increase

in particle count at the Fire Island inlet. This increase in suspended material at different locations in the photograph is also responsible for the turbidity as evident in Figure 3. The fluorometric data shows evidence of large-scale geographic changes in background fluorescence, as well as depicting the "patchings of chlorophyll".

Attention is also drawn to the appearance of light greenish color for water in the Hudson River as compared with ocean water mass and concentration of suspended material near the outlet appearing as patches of turbid water. The extinction coefficient, an index of turbidity, was calculated and, as such, relates to the suspended and dissolved material in the water. The sampling stations closest to shore generally show the highest extinction values as would be expected. It is also estimated that these stations also contain the largest number of particles per liter and phytoplankton in the water. The sampling data are being currently reduced for surface observation and a correlation will be made to the ERTS imagery on a simple date and temporal basis in the Phase III portion of this investigation.

Aircraft Imagery

NASA, Moffet Field, California, has been supplying aircraft imagery for support of this study. Considering the scope of the investigation, the quantity of imagery supplied under the aircraft program is adequate. The quality is generally good, but in some cases the imagery is not usable. Imagery taken over Block Island Sound and Long Island's South Shore area

in color infrared could not be used due to overexposure, while the imagery taken in multispectral format is of good quality. Black-and-white imagery in the following bands has been provided: 475-575 nm, 580-680 nm, and 690-760 nm.

Aircraft imagery taken on 8 June, 20 July, and 23 September 1972 could not be used either due to underexposure or more cloud coverage than desired, although photography taken in multispectral format on 23 September 1972 is being used. Also good quality imagery taken on 21 August 1972 and 28 March 1973 is being employed for extracting the information necessary to relate the water sample measurements with the satellite data.

It is believed that an ideal operational system would consist of three activities simultaneously; namely, data collection by ERTS, aircraft photographing the area, and water sampling the test sites. As the limitations to this kind of situation are noted, additive color analysis of the black-and-white multispectral aircraft imagery, taken on the dates closest to that of the satellite, is being performed. The observations and results of this analysis for surface current patterns, differences in water mass, and spectral differences can be approximated and projected to assist in the correlation of water mass characteristics with the ERTS imagery.

Water Sampling Program

It is estimated that as of this time, approximately 90 percent of the field sampling effort has been completed. The ground truth experimen-

were undertaken by the New York Ocean Science Laboratory. In the reported period, January through June 1973, ten cruises involving the research vessel KYMA were planned to collect water samples in Block Island Sound and New York Bight area. Eight of these planned cruises were executed and two had to be aborted due to the bad weather.

In order to collect water sample data which is relevant to the characteristics being detected on the multispectral imagery, the ground truth collection program was modified as compared to the methods used in the earlier part of this investigation. Surface data at a large number of stations was obtained instead of concentrating on "in depth" sampling at a relatively small number of stations. The locations of different sampling stations along the South Shore of Long Island is shown in Figure 1. In addition, nine other stations were sampled in the New York Bight area. Measurements in the Block Island Sound area were taken along the H, HB, and BR transects at different locations shown in Figure 4. During each cruise, samples were collected for temperature, salinity, nutrients, oxygen, pigments, organics, phytoplankton, light attenuation, and fluorometric readings. The following table shows the accomplishments of the cruises since the last interim report TR-20-I in December 1972.

Date	Cruise	Remarks
19,20,21 Dec. 1972	K-7239	New York Bight. Satellite day (20th) turned out to be cloudy.
24,25,26 Jan. 1973	K-7302	New York Bight. Another cruise under clear skies; a satellite day (25th).

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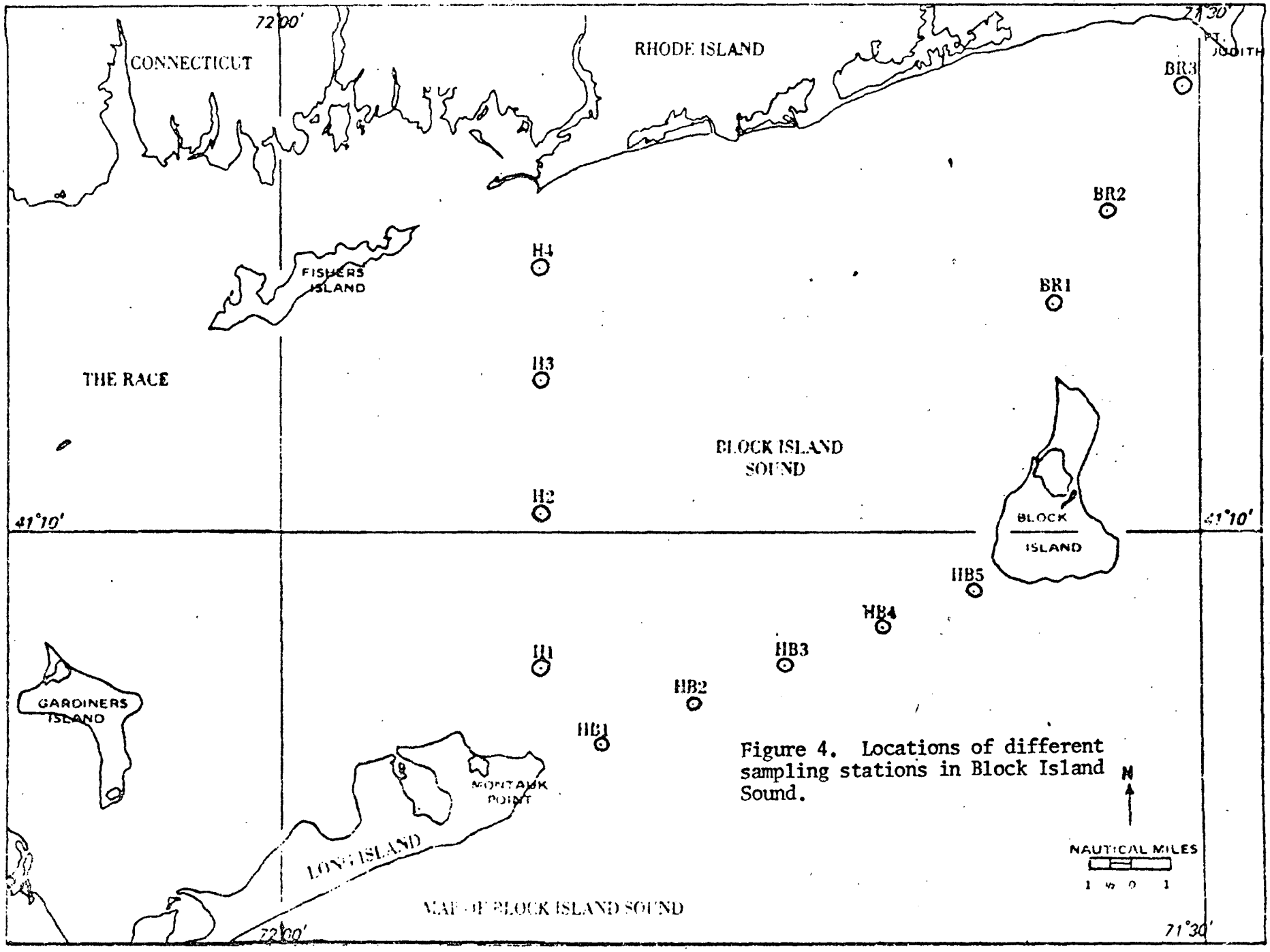

Figure 4. Locations of different sampling stations in Block Island Sound.

Date	Cruise	Remarks
13 Feb. 1973	K-7303	Block Island Sound under partly cloudy skies.
20 March 1973	K-7310	All transects, plus "H"
21 March 1973	K-7311	"BR" transect
--	K-7312	"HB" transect - cancelled due to extreme weather conditions.
24 April 1973	K-7318	All transects, plus "H"
25 April 1973	K-7319	"HB" transect
26 April 1973	K-7320	"BR" transect (terminated early due to bad weather)
30,31 May & 1 June 1973	K-7327	New York Bight cruise

The modification of the general procedure whereby, on the actual satellite day, each station on the "H" transect is sampled once and the remainder of time used for continuous profiling of all of Block Island Sound, is providing some interesting data. Large-scale changes in pigments are occurring resulting from spring blooms of phytoplankton. Increased numbers of phytoplankton are being noted around the Montauk Point area. This corresponds well to the increased numbers of particles greater than 10.7 μ in diameter in this area. This area around Montauk Point is also the area where maximum light attenuation with depth is encountered. That is to say, the most turbid waters in Block Island Sound appear to be at Montauk Point.

The temperatures throughout Block Island Sound were very nearly isothermal with temperatures ranging between 40 and 40.5 degrees Fahrenheit

(4.4 to 4.7°C) throughout Block Island Sound.

Suspended particle counts have been completed for all field trips. Differential phytoplankton counts have been completed for all field trips except May. Both suspended particle counts and phytoplankton counts increased in Block Island Sound during April, particularly in the area of Montauk Point. Differential phytoplankton cell counts indicate the presence of two distinct populations in the Block Island Sound region - one along the coast of Rhode Island and a second along the coast of Long Island. All other data are being reduced.

Suspended particle counts have been performed for the samples collected on the latest cruises in the New York Bight. Phytoplankton counts have been completed for all but the most recent field trips. A correlation is indicated between particle counts (including phytoplankton) and dense areas appearing in the photographs.

Additional measurements have been taken on all these cruises relating to the continuous fluorometric profiling of fluorescent materials (especially chlorophyll) in the seawater.

The fluorometric data is showing evidence of large-scale geographic changes in background fluorescence, as well as depicting the "patchiness of chlorophyll".

Particle counts in the western New York Bight show large increases in May as compared to previous samples. Comparison of these counts with the biological population must wait for the completion of the phytoplankton analysis.

Approximately 75 percent of the laboratory effort has been completed as of this time and continuation of the physical, chemical, and biological

oceanographic analysis of the data is underway so as to relate the water characteristics with the ERTS imagery.

Section 3

New Technology

The research reported herein involves the additive color analysis of ERTS-1 imagery and the collection of chemical, biological, and physical data in Block Island Sound and adjacent New York waters.

The description of the techniques used to create the additive color displayed has been given in Section 2 of this report.

Section 4

Program for Next Reporting Period

The oceanographic data obtained from the modified sampling program and measurements from earlier survey cruises will be analyzed with respect to surface effects which are detectable on the multispectral imagery. This mode of data reduction for physical, chemical, and biological characteristics of water masses in Block Island Sound and New York Bight area, by concentrating on the surface parameters, will be most helpful in interpreting the ERTS imagery.

The candidate frames selected from the received usable ERTS imagery will be analyzed for detailed information by using an additive color viewer. These frames would be photographically reprocessed, then evaluated for maximum water detail. Additive color, density slicing, and isoluminous analysis will be performed to achieve the maximum information regarding the spatial location and probable composition of the water masses.

Small-scale hydrographic charts will be prepared with the oceanographic information and the results determined from the analysis of water sample data. A comparison and correlation of these charts will be performed with the color composites made from ERTS imagery.

The relationship between the in situ water mass data and the analyzed ERTS imagery will be established to determine the spatial and temporal changes of water masses.

Section 5

Conclusions

ERTS-1 photographic imagery can be photographically enhanced to give color signatures which correlate with water turbidity in sewage dump areas. Bands 4, 5, and 6, when reprocessed and viewed in additive color, provide color signatures of water turbidity. By projecting Band 4 as red, Band 5 as green, and Band 6 as blue, a distinct reddish-yellow color signature which correlates with suspended materials in coastal waters is observed.

Such color signatures can be utilized to chart the position of sewage dump areas as a function of time. Thus, the dissipation of such effluent can be charted and monitored in relation to tidal currents and the effects of weather.

Section 6

Recommendations for Further Action

The modified "ground truth" data collection plan has produced extended surface data of physical, chemical, and biological water characteristics over a wide area of New York coastal waters simultaneously with the acquisition of ERTS-1 data.

The color signatures obtained by photographic enhancement of the ERTS-1 imagery will be correlated with the water data acquired. Thematic maps will be constructed which show the temporal distribution of sewage effluent and sediment discharge from coastal estuaries.